

DIBS INDEPENDENT OF ACCRETION IN T TAURI STARS

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ABSTRACT

We have examined high resolution spectra (5200 – 7000 Å) of 36 T Tauri stars ranging in accretion rates. Only the $\lambda\lambda$ 5780, 5797 and 6613 bands are detectable to within an equivalent width of 10 mÅ. They are strongest in DG Tau, DR Tau, DL Tau and AS 353A. DR Tau was monitored over the course of four years; during this time, the accretion rate varied by a factor of five, but the equivalent widths of the DIBs remained constant.

The lack of correlation of the strength of the bands with the accretion rates implies that the bands are not directly produced by UV radiation from the accretion process. The bands have line strengths and ratios characteristic of the diffuse interstellar medium (Jenniskens & Désert, 1994), from which we conclude that the diffuse interstellar bands seen in the spectra of T Tauri stars do not originate in the stars' immediate environment (Meyer & Ulrich, 1984). Instead, they are part of a foreground extinction, probably due to the parent molecular cloud.

INTRODUCTION

Since their discovery nearly fifty years ago, the identity of Diffuse Interstellar Bands (DIBs) remains a mystery. These absorption features, which appear toward many young stars, could be anything from dust grains in interstellar clouds to large molecules associated with Polycyclic Aromatic Hydrocarbons (PAHs).

Detecting DIBs in T Tauri spectra may be a clue to the origin of the bands. T Tauri stars are young, low-mass ($M < 1 M_{\odot}$) objects which are still physically associated with their parent molecular clouds. These stars are characterized by excess continuum emission produced by circumstellar accretion. This excess emission, or *veiling*, provides a smooth continuum that allows to observe DIBs in these late type stars, as shown by Meyer & Ulrich (1984). If the DIBs are local to the immediate T Tauri star environment and are produced by UV radiation, as in the large molecule hypothesis, they would be affected by the UV radiation

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coming from circumstellar accretion. As the accretion rate increases, so would the equivalent width of the bands. However, if DIBs originate in interstellar material, they would be untouched by the UV flux from near the T Tauri star.

In this contribution, we examine the nature of DIBs by studying their line strength in the spectra (5200 – 7000 Å) of 36 T Tauri stars ranging in accretion rates.

VEILING

Many low-mass pre-main sequence stars show evidence for circumstellar disk accretion. This disk accretion produces a hot ($T \sim 10,000$ K) region between the central star and the inner disk. This region is the source of the excess *continuum* emission, known as *veiling*, observed in the spectra of T Tauri stars.

We quantify veiling, and subsequently accretion, by adding a constant, k , to the spectrum of a standard with a spectral type identical to that of the T Tauri star. We then define the veiling parameter, τ , as the ratio of flux of the excess to the flux of the standard:

$$\tau = \frac{k}{std\ continuum}$$

It is important to note that this technique of measuring accretion is *independent* of reddening since it depends solely on the depth of the photospheric features relative to the continuum.

Figure I illustrates how we quantify optical excess emission in T Tauri stars. In both panels, the solid line represents the observed spectrum of BP Tau (K7) obtained from high resolution ($\Delta\lambda \sim 0.1$ Å) KPNO echelle spectrograms. The dashed line represents the spectrum of a standard star of identical spectral type. The first panel compares the spectrum of BP Tau with a standard of matching spectral type; note that the spectral features of the standard are deeper (relative to the continuum) than those of BP Tau. In the second panel, the standard has been artificially "veiled", by adding a constant to the observed spectrum, with a veiling flux to photospheric flux ratio, τ , equal to 0.9 (see Hartigan *et.al.*, 1991).

DIBS IN T TAURI STARS

After subtracting the spectrum of a standard T Tauri star, of same spectral type but with no detectable DIBs, only the strongest DIBs are detected in the program stars: the $\lambda\lambda$ 5780, 5797 and 6613 bands, to within an equivalent width of 10 mÅ. Out of a total of 36 T Tauri stars, only 6 show signs of DIBs. The bands are strongest in DG Tau, DR Tau, DL Tau and AS 353A. The table below lists the veiling and the equivalent widths of the T Tauri stars with detectable bands. The 6203 and 6195 bands are not detected, and the 6284 band is obscured by atmospheric oxygen bands.

DIBS AS FUNCTION OF VEILING

The accretion rate of DR Tau varied by a factor of five during the four years that it was monitored. The accretion rate of DF Tau varied by a factor of

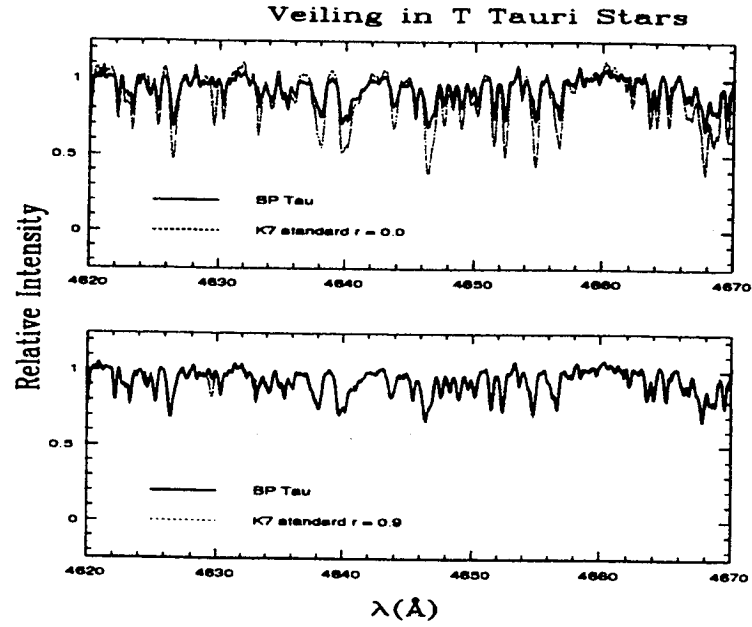


FIGURE I An illustration of how optical excess emission for T Tauri stars is quantified.

TABLE I Measurements of DIBs in T Tauri Stars

Object	Spectral Type	r	v_r ($km\ s^{-1}$)	$W_\lambda\ 5780\text{\AA}$ (\AA)	$W_\lambda\ 5797\text{\AA}$ (\AA)	$W_\lambda\ 6613\text{\AA}$ (\AA)
DF Tau	M2	0.5	14.5	0.060 ± 0.015	0.06 ± 0.01	0.041 ± 0.008
		0.7	17.1	†	0.07 ± 0.01	0.03 ± 0.01
		1.6	17.9	0.02 ± 0.01	0.050 ± 0.007	0.05 ± 0.01
DG Tau	K7/M0	2.0	18.8	†	0.058 ± 0.007	< 0.02
		3.0	23.3	†	0.06 ± 0.01	< 0.02
		3.6	20.1	0.04 ± 0.01	0.03 ± 0.01	0.030 ± 0.015
DL Tau	K7/M0	1.1	18.8	†	0.05 ± 0.015	0.03 ± 0.01
		2.1	18.1	0.03 ± 0.01	0.03 ± 0.015	0.02 ± 0.01
DR Tau	K7/M0	4.5	21.6	0.038 ± 0.006	0.009 ± 0.006	0.047 ± 0.007
		6.8	25.5	0.043 ± 0.006	0.020 ± 0.010	0.040 ± 0.008
		8.4	26.2	0.033 ± 0.012	0.015 ± 0.006	0.050 ± 0.004
		20.0	19.9	0.048 ± 0.006	0.023 ± 0.009	0.049 ± 0.004

†overlying emission

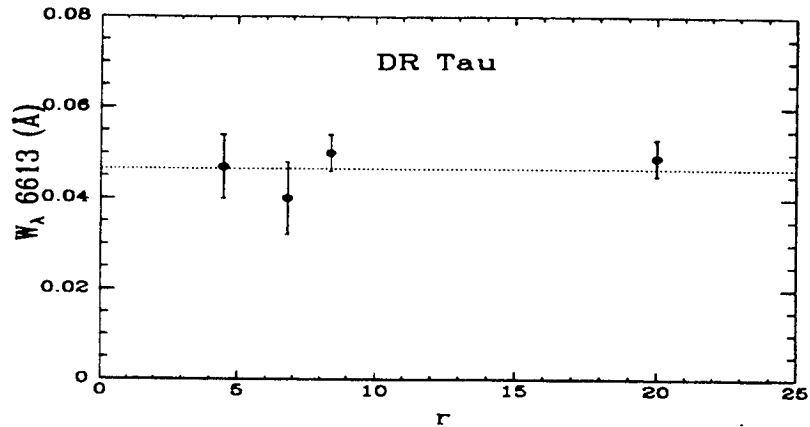


FIGURE II Independence of DIB strength on the UV flux near the central star.

three, DL Tau by a factor of two. The equivalent widths of the DIBs *remained constant*. The lack of correlation of the strength of the bands with the accretion rates implies that the bands are *not* produced by UV radiation from the accretion process.

We think the case is particularly strong for DR Tau. Figure II plots the equivalent width of the $\lambda 6613$ line vs. the veiling parameter, r . The dashed line represents the average value of measured equivalent widths. Note that, even though the accretion rate differs by a factor of five, the line strength of the $\lambda 6613$ band remains constant. Therefore, DIBs are independent of accretion in T Tauri stars.

CONCLUSIONS

- We have examined high-resolution spectra of 36 T Tauri stars for DIBs, out of which 6 show DIB absorption features.
- Only the strongest DIBs, $\lambda\lambda$ 5780, 5797 and 6613, are present.
- We compare the DIB strength with the simultaneous measurement of veiling (accretion rate), and find that the *DIB strength is independent of the UV radiation from the accretion process*.

REFERENCES

- Hartigan P., Kenyon S.J., Hartmann L., Strom S.E., Edwards S., Welty A.D., Stauffer J. 1991, ApJ, **382**, 617.
- Jenniskens P., Désert F.-X, 1994 A&AS, (*in press*)
- Meyer D. M., Ulrich R. K., 1984 ApJ, **283**, 98.